

## CLAIMS

What is claimed:

1. A method of forming a copper layer on a substrate, comprising:  
forming a copper oxide layer from a non-fluorine containing copper precursor on the  
5 substrate; and  
reducing the copper oxide layer to form a copper layer on the substrate.
2. The method of Claim 1 wherein the steps of forming a copper oxide layer and  
reducing the copper oxide layer are carried out at substantially the same temperature.
3. The method of Claim 2 wherein the steps of forming a copper oxide layer and  
10 reducing the copper oxide layer are carried out at a temperature in the range of about 100 to  
300°C.
4. The method of Claim 1 wherein the step of forming a copper oxide layer comprises  
depositing the copper oxide layer by atomic layer deposition comprising alternatively  
reacting the surface of the substrate with a non-fluorine containing copper precursor and an  
15 oxygen containing gas, at a temperature below about 200°C.
5. The method of Claim 4 wherein the non-fluorine containing copper precursor is a  
copper alkoxide, copper  $\beta$ -diketonate or copper dialkylamide.
6. The method of Claim 5 wherein said copper alkoxide comprises  $[\text{Cu}(\text{t-BuO})]_4$ , said  
copper  $\beta$ -diketonate comprises  $\text{Cu}(\text{tetramethylheptadionate})_2$ , and said copper dialkylamide  
20 has the formula of  $[\text{Cu}(\text{NR}_2)]_4$  where R represents alkyl.
7. The method of Claim 4 wherein said oxygen containing gas is ozone, oxygen, water  
or any mixture thereof.
8. The method of Claim 1 wherein the step of reducing the copper oxide layer comprises  
reducing the copper oxide layer by contacting with a hydrogen containing gas at a  
25 temperature below about 200°C.

9. A method of forming a copper film on a substrate, comprising:  
introducing a non-fluorine containing copper precursor gas about a substrate provided  
in a chamber;  
removing excess copper precursor gas from the chamber;  
5 introducing an oxygen containing gas into the chamber to form a layer of copper  
oxide on the substrate;  
removing excess ozone from the chamber; and  
introducing a hydrogen containing gas into the chamber to reduce the copper oxide  
layer to form a copper layer.
- 10 10. The method of Claim 9 wherein the steps of forming the copper oxide layer and  
reducing the copper oxide layer are carried out at a temperature of below about 200°C.
11. The method of Claim 9 wherein the steps of forming the copper oxide layer and  
reducing the copper oxide layer are carried out at a pressure in the range of about 100 mTorr  
to 10 Torr.
- 15 12. The method of Claim 9 wherein the non-fluorine containing copper precursor is a  
copper alkoxide, copper  $\beta$ -diketonate or copper dialkylamide.
13. The method of Claim 12 wherein the non-fluorine containing copper precursor is  
selected from the group consisting of  $[\text{Cu}(\text{t-BuO})]_4$ ,  $\text{Cu}(\text{tetramethylheptadionate})_2$ , and  
copper dialkylamide.
- 20 14. The method of Claim 9 wherein the oxygen containing gas is ozone, oxygen, water,  
or any mixture thereof.
15. The method of Claim 14 wherein the oxygen containing gas is ozone.
16. The method of Claim 9 wherein the copper precursor is introduced at a flow rate in  
the range of about 1 to 1000 sccm.
- 25 17. The method of Claim 9 wherein the copper precursor is introduced in pulse at a pulse  
time of about 0.01 to 10 seconds.

18. The method of Claim 9 wherein the oxygen containing gas is introduced at a flow rate in the range of about 100 to 2000 sccm.